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The necessity of dust control has long been recognized. The most common medium for dust control has been, and in most instances continues to be the use of water applied as often as necessary to "lay the dust".

To achieve a reduction in the cost of frequent water sprinkling, hygroscopic salts have been used in areas of relatively high humidity and diluted mixing type asphaltic emulsion has been tried by a number of states. Recently a number of new products have made their appearance on the market.

On many of our California highway construction jobs the new project parallels the present travelway or borders residential areas where the presence of dust in the air becomes a serious problem. In order to study the performance and possible economic advantages of various dust binders, a number of test sections were placed in the median strip on a recent highway project. The following dust binders were used: water, diluted asphaltic mixing emulsion, a lignin product and an asphaltic resin product. Water proved to be the most expensive and for the most part the least effect method of combating the dust.

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DUST CONTROL DURING CONSTRUCTION OPERATIONS

By
Ernest Zube
Supervising Materials and Research Engineer

Presented at the 39th Annual Meeting
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Ernest Zube*

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Introduction

During construction of our highways, the type of soil encountered combined with certain weather conditions are often times conducive to extensive dust formation especially in the more arid regions. Dust becomes a serious hazard to traffic, is detrimental to orchards, increases the cost of equipment maintenance and constitutes a nuisance to residential areas if in the immediate vicinity of the job site. Dust also presents a definite health hazard to working men.

Agencies engaged in heavy construction and some allied industries have long recognized the necessity of dust control. The most common medium for dust control has been, and in most instances continues to be, the use of water, applied as often as necessary to "lay the dust".

In order to reduce the cost of frequent water sprinkling, certain hygroscopic salts have been used in areas of relatively high humidity and diluted mixing type asphaltic emulsions have been tried by a number of States. Recently a number of new products have been developed and have been used on haul roads, certain open pit coal and ore mining operations and in connection with the operation of air fields.

On a recent highway construction project the new construction paralleled the existing roadway. The type of soil encountered in the new median strip and strong prevailing winds, created a serious dust hazard to the traveling public. In order to study the performance and possible economic advantages of various dust binders, a number of test sections were placed in the median strip area.

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Description of the Test Site

The project consisted of constructing 5.6 miles of new concrete pavement between 1.0 miles north of Greenfield and the Salinas River on U. S. Route 101 in Highway District V. It was constructed during 1957 under Contract 58-5TC4F. The route location is referred to as V-Mon-2-D. The new alignment parallels the existing two lane highway throughout the entire 5.6 miles. The new roadbed is raised above the existing travelway and necessitated extensive grading on the median strip. The new median varies from 35' to about 100' in width with 1:6 side slopes (See Fig. 1 and 2).

Soil conditions on about 80% of the job makes the area highly susceptible to severe dust formation, especially where the median is the widest. Unfortunately this area also has a serious wind problem during the summer months. Winds of 25 to 30 miles per hour occur almost daily in the Salinas Valley, and on the job site such winds began about eleven a.m. and subsided about seven p.m. The wind direction was almost parallel to the major portion of the project. A serious dust hazard developed shortly after start of construction requiring extensive and continuous sprinkling with water up to the time of the laying of the test sections.

Design

During discussions with the Resident Engineer the following information was obtained relative to the dust problem on this contract. Dust formation was very severe between stations

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180± and 400±. From station 108 to 180±, the new construction is in an area of rather granular rocky material, which only generated minor amounts of dust. It is interesting to note that this area continues southward beyond Greenfield where a similar job was built without any serious dust hazard. Actually, the farming region also terminates in this area, indicating a marked change in soil characteristics. The field observations are further substantiated by the results of sieve analysis and sand equivalent tests on representative samples from the median strip, as shown in Table I.

The most severe dust formations occurred between stations 180± and 325±. It will be noted from Fig. 1 that the median strip is quite wide in this area and the prevailing winds, averaging 20-25 miles per hour blow almost parallel to the alignment. It appears that the slight difference in intensity of dust formation between stations 180 to 325 and 325 to 400± is due to the change in alignment and the differences in median width. After consultation with the Resident Engineer, a series of test sections were laid out and the necessary quantities of concentrates for the various types of proposed dust binders were determined and ordered.

The final test section, Fig. 1, was based on the objective of comparing a number of known commercially available dust binders at dilutions recommended by the vendors. Mixing type asphaltic emulsion, a petroleum resin product, and a lignin sulfonate were chosen for the trial.

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The properties of the standard mixing type emulsions are well known and no further description is required. The petroleum resin binder is a concentrated emulsion composed of semi-liquid petroleum resins together with wetting agents and water. The concentrate may be further diluted with varying proportions of water. The wetting agents increase the spreading power of the diluted emulsion and also increase the penetration into the dust layer. The active binder agent, for the dust forming particles, is the petroleum resin fraction. Since this fraction is derived from petroleum, it is insoluble in water and is not leached out by rain. It is of a yellowish color and shortly after application the treated surface appears almost the same color as the original ground. The lignin sulfonate is derived from waste products obtained in the manufacture of paper products. The material is a lignin chemical and contains a complex of chemical compounds derived from wood pulping. It may be purchased as a powder or a water solution containing 50% solids. The water solution was used on this job because of the economics of shipping and handling on the job site. It is composed of active surface chemicals and, therefore, acts as both a wetting and binder agent. The cementing agent itself is soluble in water and to some extent can be washed out by rain. The treated surface appears quite dark, assuming a dark brown color when treated with the more concentrated solutions.

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An effort was made to place some of the various dilutions of each type of binder in areas of different dust intensity. Two controls were also established in order to determine the comparative water costs.

Construction

All of the test sections were placed on August 12, 13 and 14, 1957. The various binders were stored on the job site in trailers and spreading was performed with a standard asphalt distributor.

The materials were pumped into the distributor from the storage trailer and water was added to produce the desired dilution. In the case of the lignin and asphalt emulsion, the binder was first pumped into the distributor and then the water added. With the petroleum resin dust binder, the concentrate was added after the water in order to reduce foaming. In all cases, no extra agitation was necessary for blending. The water was under high pressure and dropped from an 8" standpipe through the manhole on top of the distributor into the tank. This caused a pronounced surging action which aided in mixing. It should be noted that both the lignin and resin dust binders have additives incorporated in the concentrate for promoting a very rapid mixing in high dilutions.

One of the difficult field decisions in the use of any dust binder is to determine the best spread rate for the particular soil being treated. On this job, the median area

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between stations 180+ and 400+ had been extensively watered over a period of about one month. The movement of the water trucks had compacted the material in the top 1/4" to 1/2", and coupled with the fact that the major portion of the median was on a fair slope indications were that a runoff might be expected during spreading operations. Preliminary trials, with a hand watering can, indicated that definite penetration could be obtained, with a minimum of runoff, when a maximum of 0.25 gallons per sq. yd. was spread. Recommendations from the producers literature indicated that 0.5 gallons per sq. yd. should be satisfactory in preventing dust formation on an area not subjected to traffic movements. Therefore, it was decided to spread a total of 0.5 gallons per sq. yd. with two passes of 0.25 gallons per sq. yd. This procedure was followed throughout all of the test sections. Some difficulties were encountered in establishing the spread rate and a number of trials were necessary, since the available charts for spreading the more viscous asphalts proved useless with these dilutions. However, final calculations indicate that an average of 0.56 gallons per sq. yd. was spread in the lignin and resin test sections and 0.54 gallons per sq. yd. in the emulsion sections. The final spread rates show that calibration trials are necessary, when using normal oil or asphalt spreading equipment. These trials only required a short delay on the morning of the first day.

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The normal procedure was to make the first pass forward, back up along the test section, and then immediately spread the second pass over the same strip. On the first pass there was very little runoff on the slopes, and penetration was about 1/8 to 3/16" with the second pass showing a slight runoff, Fig. 3. On one of the sections an attempt was made to increase the total spread by a third and fourth pass over the upper portion of the slope of the median. There was considerable runoff and it was evident that 0.5 gallons per sq. yd. was the maximum amount that would properly penetrate and stay on the slope. It is interesting to note, that good penetration with no runoff was achieved with the same spreading procedure, in the area between station 114 and 180± where a rather rocky, granular material was encountered. There were no difficulties in spreading operations with the various dilutions of the three dust binders laid in the test sections.

Evaluation Studies

Approximately twenty-four hours after completion of spreading, the test sections were evaluated on the basis of surface appearance and dust formation, see Fig. 6.

The lignin treated sections of 1:5 and 1:10 dilutions, were a darkish brown shortly after spreading. They tended to form a definite crust on the surface which began to crack and curl slightly in some areas, about twenty-four hours after spreading, Fig. 4. The penetration appeared to vary

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from 1/16 to 3/16". After forty-eight hours the crust tended to crack into small blocks roughly 3- by 3-in., with a tendency of the edges of the blocks to curl upwards. These blocks did not separate from the underlying material and no dust or distress was noted in the sections with winds averaging 20 to 25 miles per hour.

The petroleum resin sections gave a yellowish brown appearance after completion of spreading. Penetration was the same as in the lignin sections; but no cracking or curling was noted, even in the 1:4 dilution.

The asphaltic mixing emulsion, 1:10 dilution turned very black, shortly after spreading. The asphalt appeared to have formed a mat at the surface although it was quite tightly bound to the underlying material indicating at least a partial penetration of the emulsion prior to separation of the asphalt. At the end of twenty-four hours the section was in excellent condition. There was no cracking or curling of the thin asphaltic membrane covering the surface. The original plan also called for a 1:20 dilution of emulsion, but the quantity available did not provide a sufficient volume and the final dilution was 1:30. It was surprising to note that this high dilution provided a darkish brown surface, with quite good penetration. One could definitely tell that a treatment had been performed. After twenty-four hours the section looked good with no cracking or curling.

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As mentioned previously, the median strip on Monday morning, August 12, was in a tightly compacted condition. Water had been placed on the median during the night and it was decided to stop all sprinkling in order to secure maximum penetration of the dust binders. Because of problems involving transfer of the concentrates to storage trailers and checking of spread rates, only one section, the lignin 1:5, was completed by noon. About 11 a.m. the wind began to blow and by 1 p.m. the wind velocity was averaging around 20 miles per hour, with gusts up to 25 miles per hour. By 1:30 p.m. visibility on the adjacent travelway had been reduced by dust from the median so that lights were required. The photographs shown in Fig. 5 indicate the extent of dust formation.

All of the test sections were completed by noon on Wednesday, August 14. At 11:00 a.m. the wind again started and reached Monday's velocity by 1:00 p.m. No water had been applied to any of the test sections, except the controls, after spreading was completed and although high winds persisted throughout Wednesday afternoon and evening, there were no signs of dust. Photographs shown in Fig. 7 show the lack of dust over the treated sections. We may conclude that dust formation had been completely reduced by all of the various dilutions of dust binder concentrates placed in the test sections.

Generally, to justify the use of dust binder agents, it is necessary to prove that they are more economical than the normal method of sprinkling with water. In order to prepare an

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economic analysis for this job, two control sections were established for the purpose of determining water costs during the evaluation period. The Resident Engineer maintained costs on watering of the control sections during a twenty-three day period, following completion of the dust binder sections. During this interval 138,000 gallons of water were applied to Control #1, station 265-380; and 104,000 gallons to Control #2, station 200-220. At a price of $1.75 per 1000 gallons of water, including supplying, hauling and spreading, we obtain an average figure of $0.0009 per sq. yd. per day for cost of water on the control sections, during the twenty-three day evaluation period. This cost figure is considerably lower than the watering costs of the entire median during a ten day period just prior to spreading the test sections. The cost of watering the entire median of about 161000 sq. yd. (total treated sections plus two controls) as furnished by the Resident Engineer amounted to $450.00 per day.

$$\text{or: } \frac{450.00}{161000} = \$0.0028 \text{ per sq. yd. per day}$$

It is apparent that the controls were not watered as much as equivalent areas prior to treatment. This was due to the fact that the dust generated from the comparatively small areas of the two controls, was less hazardous to traffic in comparison to the dust generated from the original total median area. It therefore appears reasonable to assume that the figure obtained from the cost of sprinkling the entire median during the ten day period just prior to treatment should be used for economic comparisons.

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The total costs per sq. yd. for the various dust binder dilutions are shown in Table II. The direct comparison with the cost of watering is also shown on the basis of the number of days that each test section must provide against dust formation before the costs of the dust binders equals that of applying water. It will be noted that this "break even" period varies from four to fourteen days.

An evaluation study was made on September 18 and 19, 1957, or thirty-five days after placement. At this time, all of the test sections that had not been disturbed by construction activity, were in good condition and were fully effective in preventing dust formation without additional watering. A very small amount of water was being used on areas adjacent to shoulder construction where blading operations had torn up the surface and along the shoulder edge of the existing travelway. No water had been applied to any undisturbed areas of the treated sections since the original spreading operations. On the basis of the thirty-five day evaluation period, the saving by treatment amounted to $391.49 per day for each day beyond the "break even" point for any specific dilution. The $391.49 figure was obtained by multiplying the total treated area, 139,819 sq. yds. by the average water cost per sq. yd. per day for the ten day period prior to treatment. In other words, if the most expensive treatments, lignin 1:5 or resin 1:4 had been placed over all of the test sections then at the end of fourteen days of no watering, such treatment would have paid

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for itself. The continued protection up to the evaluation period of thirty-five days had saved $8221.00 ($391.49) x 21 days).

Figuring one of the less expensive treatments with an average "break even" point of eight days, the actual saving amounted to $349.49 x 27 days or $9,436.00.

The surface appearance of the test sections was such that it could reasonably be assumed they would give additional protection from dust formation for at least another fifteen days or even longer if not disturbed by construction equipment. On this basis, the actual saving to the State could have amounted to $349.49 x (50-14) days or $12,582.00 for the most expensive treatment and $349.49 x (50-8) days or $14,679.00 for the less expensive treatment.

The survey made after thirty-five days indicated that all of the various sections were performing in a satisfactory manner, with the same general wind conditions encountered prior to treatment, Fig. 8. The general appearance of the test sections may be summarized as follows:

1. Lignin sulfonate 1:5 and 1:10 dilutions still appeared quite dark, with quite extensive cracking and curling in the 1:5 section. This cracking and curling had not caused separation of the crust from the underlying layer and no evidence of dust formation was present.

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2. All of the various petroleum resin dilutions showed a remarkable change in color from the original. The sections gave no appearance of having been sprayed and showed no signs of cracking or curling as noted in the lignin section. On close inspection one could detect yellowish-like streaks where runoff had occurred during the second pass. Although these sections had assumed the color of the native soil the treatment provided full protection against dust formation at wind velocities exceeding 25 miles per hour.
3. There was no major change in the appearance of the emulsion sections. There was no evidence of drying out or cracking and curling.

The condition of the various sections definitely indicated that protection in undisturbed areas would continue for a much longer period of time.

Plant Growth

The treatment of median strips and other areas where future plant or grass growth is planned, has raised the question as to whether dust binders will tend to retard or destroy such growth. In the case of the three agents, discussed here, there are reasons for believing that such growth might be accelerated.

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The lignin compound is water soluble and is relatively easily decomposed by soil bacteria, thereby enriching the soil. In fact, the only evidence of growth on the median strip was in the lignin sections where small amounts of alfalfa had started to grow, thirty-five days after application. Previous studies by the Air Force with the resin compound on a twenty acre semi-desert location clearly showed an improvement in weed growth when compared with an adjacent untreated control area. All of these agents, including the diluted asphaltic mixing emulsion tend to prevent the upper layer of soil from drying out, and because of their dark color, they tend to increase the soil temperature near the surface, thus providing more favorable growing conditions.

Other Applications

One of the important factors in the decision to use a dust binder is the amount and price of water considered necessary for dust abatement on any specific project. If the water requirement is quite low, then the "break even" period may be extended beyond the period requiring dust control and the binders may prove too expensive as compared to water costs, although some monetary consideration should be assigned to the complete absence of dust at all times.

Consideration must also be given to other conditions on the job site. It should be stressed that, in using any form of dust binder, one must realize the marked differences between conditions encountered in undisturbed areas such as

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are cited in this report and those found on a haul road or detour under traffic. A single treatment, that may adequately protect an undisturbed area, may provide only a temporary protection for a heavily traveled haul road or detour. In most cases, where serious dust formation is encountered, the soil is extremely fine and if dust is present at the time of treatment, the actual penetration may be quite low even in high dilutions. The movement of vehicles, especially heavily loaded construction equipment, will disturb and break up the surface layer and immediately generate dust. It is, therefore, logical to expect that more frequent treatment will be necessary in such cases.

We have performed some preliminary studies on the use of dust binder agents on haul roads and detours. An economic analysis is complicated by the amount and type of traffic and the necessity for retreatment as the original treated surface is abraded or raveled away.

On one contract, traffic was routed through the job over 7.8 miles of untreated rock base. Prior to the start of paving operations a severe dust problem had developed and considerable water was required. Although such watering reduced the hazard to traffic, there were times when there was sufficient dust in the air to be annoying. Therefore, mixing type emulsion was tried, by treating six sections varying from 1000' to 10000' in length. A 1:10 mixture was used and applied from the water truck at about the same speed as with normal watering operations. On three of the sections,

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two spreads were made and on the other three only one spread. The penetration on all sections was quite good and the results were effective at the start and one of the two water trucks previously used was eliminated.

Three weeks later the entire area required blading because of raveling, and watering was again required on all of the treated sections. However, it was noted that the water requirements on these reworked treated areas was considerably less than before the application of the diluted emulsion.

The following conclusions were drawn by the Resident Engineer on the basis of his observations: "A conservative estimate in the amount of water saved by using the diluted emulsion also showed a savings in money since water on this contract was priced at $1.50 per M-gallons. In addition other benefits were realized, such as more effective control of dust at all times, day and night, and less annoyance to traffic".

On another contract, approximately six thousand feet of processed selected material had been laid. This section was being used by the contractor for heavy hauling operations and was adjacent to homes and several orchards where choice fruit was grown. Although the surface was extensively watered, many complaints were received because of dust raised by the passage of trucks. The 6000' stretch was divided into three 2000' sections. One of the sections was established as a control and watered at the same rate as previously used.

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On one section an initial treatment of 0.7 gallons per sq. yd. of a petroleum resin dust binder in 1:7 dilution was applied and after penetration followed by 0.3 gallons per sq. yd. of the same dilution. On the other treated section a mixing type asphaltic emulsion was used at the same application rates, but with a 1:10 dilution. The heavy volume of traffic required periodic retreatment. In the case of the resin section these treatments involved an application of 0.2 gallons per sq. yd. of either a 1:10 or 1:20 dilution and the emulsion was applied at the same rate, but at a 1:10 dilution.

The study was continued for a period of 83 days, during which there was no rain, and traffic included not only heavy duty trucks, but also DW20 scrapers. During this interval the petroleum resin section was treated seven times and the emulsion section three times. However, the comparison is complicated by the fact that in four of the seven treatments the resin binder was applied at 1:20 dilution, whereas a 1:10 dilution was used for the asphalt emulsion.

During the 83 day test period the total costs for each section were: Water control = $496, Resin = $588, and Emulsion = $279. The emulsion treatment showed a definite saving based on the relatively high cost of water at $1.50 per M gallons.

The Resident Engineer, who observed the areas during the test period, states, "Both materials were more effective than water in controlling dust. In both treated sections the

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development of dust was very slow, allowing the scheduling of a supplemental application well in advance of critical dustiness."

The additional advantages of more positive control of dust and the fact that watering alone may not adequately control dust formation indicates that in some cases a dust binder should be used even though the final cost is higher. Our experience to date indicates that the use of dust binders on haul roads must be decided on the basis of each individual job and economical considerations may not be the most important factor.

Conclusions

The studies outlined in this report clearly indicate the economic advantage of treating dust areas whether undisturbed by equipment or traffic or consisting of haul roads with some type of dust binder, other than water. In the first cited example, Contract 58-5TC4F, the saving to the State by using dust binders is estimated to be about $10,000.00. The various binders can be easily diluted with water and spread with normal construction equipment. The additional advantage of more positive dust control indicates that in some cases a dust binder should be used, even though the final cost is somewhat higher when compared with watering.

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Table I

Grading and Sand Equivalent Values for Soils Found in the Median on Contract 58-5TC4F, Road V-Mon-2-D

Test No.	Sta. to Sta.	Dust Formation	Grading - % Passing														Sand Equivalent
			2"	1-1/2	1	3/4	3/8	4	8	16	30	50	100	200	5μ	1μ	
57-1870	110+00 to 180+00	Slight	100	97	92	87	79	74	69	60	47	24	12	7	4	3	75
57-1871	180+00 to 240+00	Moderate to severe		100	99	98	96	95	93	88	73	49	31	20	10	8	35
57-1872	240+00 to 310+00	Severe						100	99	99	96	91	80	63	25	16	9
57-1873	310+00 to 400±	Moderate to severe					100	99	98	97	93	78	62	57	27	17	11

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Table II

Cost Analysis for Dust Binder
Agents Used on Contract 58-5TC4F
Road V-Mon-2-D

Dust Binder Type	Dilution	Total spread area sq.yds.	Spread rate gals per sq.yd.	Cost of			Total	Cost of dust binder per sq.yd.	Cost of water per sq.yd. per day prior to treatment	Break even point for dust binder in days
				Dust binder conc.	Water	Spreading				
Petroleum Resin Compound	1:4	22,677	0.56	$749.30	$17.78	$ 90.71	$857.79	$ 0.038	0.002	14
	1:7	9,750	0.56	201.19	8.37	39.00	248.56	0.026	0.002$	9
	1:10	32,000	0.56	480.56	28.51	128.00	637.07	0.020	0.002$	7
Lignin Sulfonate	1:5	25,117	0.56	850.87	20.51	100.47	971.85	0.039	0.002$	14
	1:10	22,500	0.56	415.64	20.06	90.00	525.70	0.023	0.002$	8
Asphaltic Mixing Emulsion	1:10	12,750	0.54	188.43	10.96	51.00	250.39	0.020	0.002$	7
	1:30	14,966	0.54	78.56	13.69	59.86	152.11	0.010	0.002$	4

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DUST BINDER TEST SECTIONS
ROAD V - MON - 2 - D
Test Sections Laid on
Aug. 12, 13 & 14 - 1957

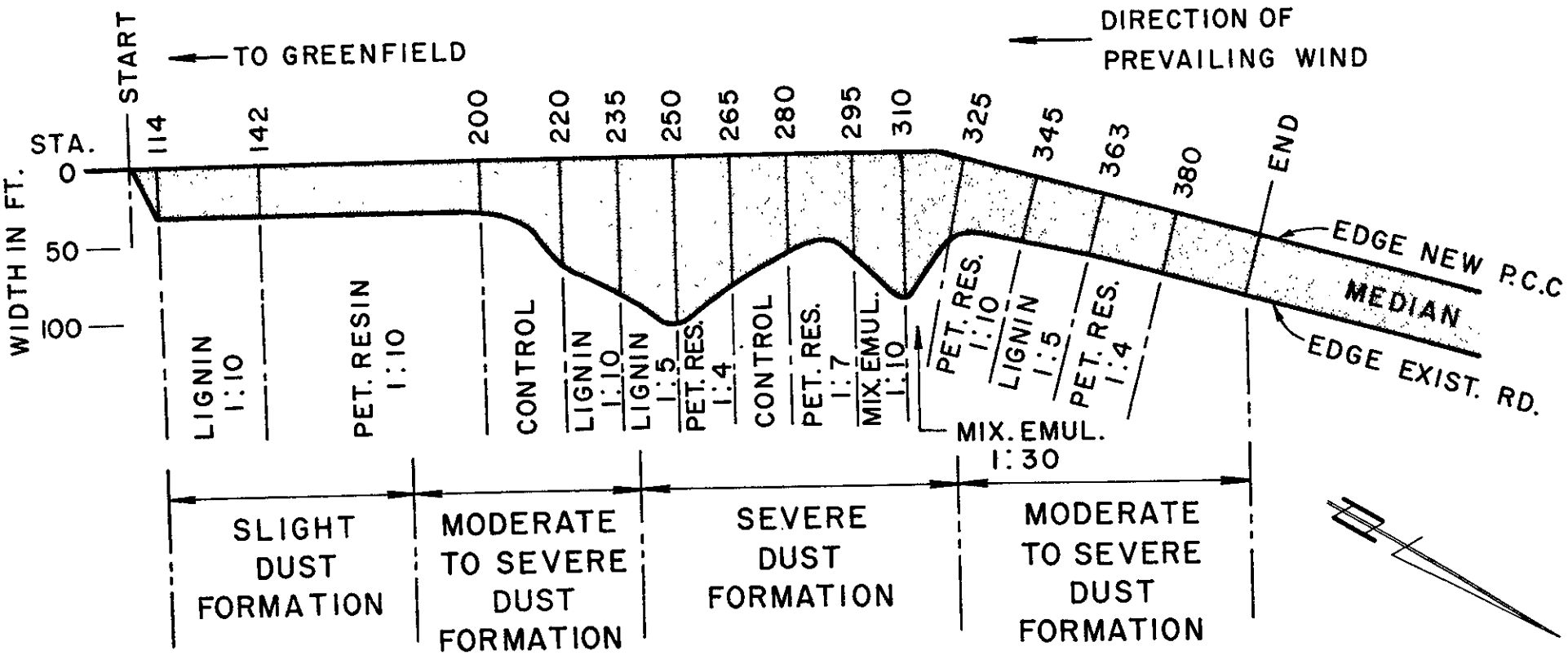

Fig. 1

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CROSS SECTION
DUST BINDER TEST SECTIONS
ROAD V - MON - 2 - D

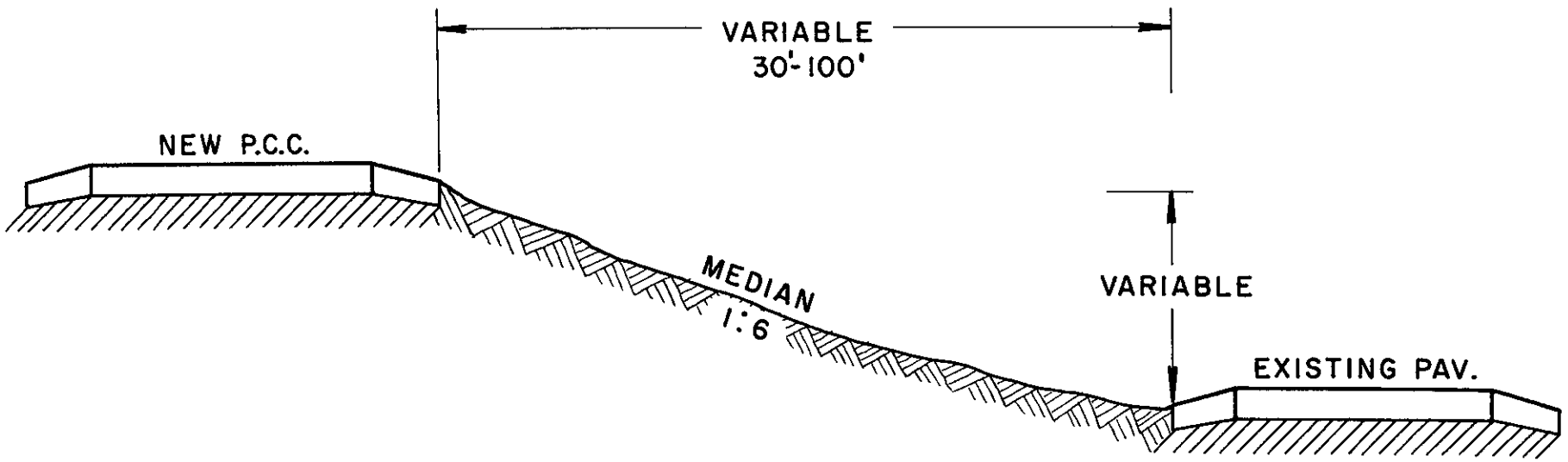
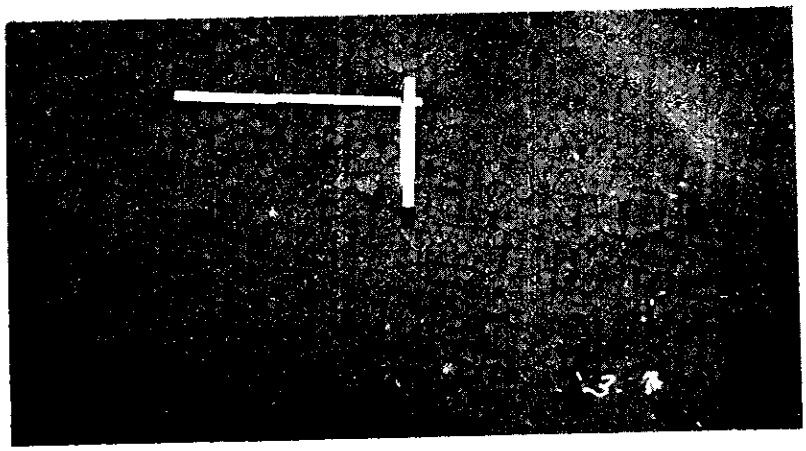


Fig. 2

Fig. 3

Typical appearance of various dilutions of dust binders immediately after first spread of 0.25 gals./sq.yd. on median slope. None or only very slight runoff was noted on the first pass.

Fig. 4



Lignin Sulfonate 1:5 test section showing cracking and beginning of curling of edges of small blocks 24 hours after application.

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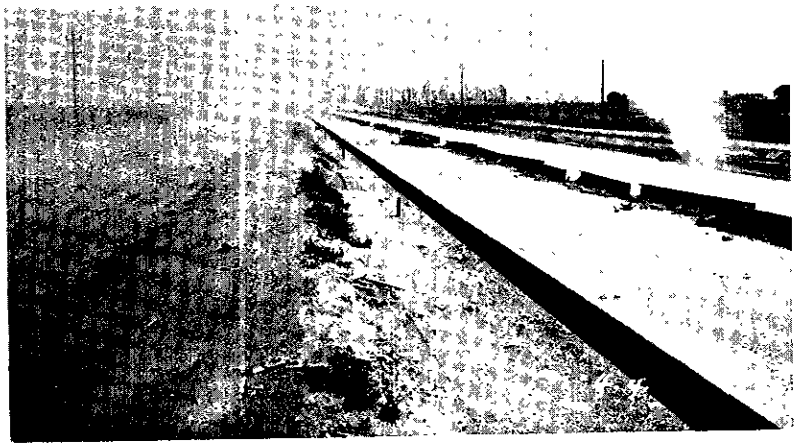

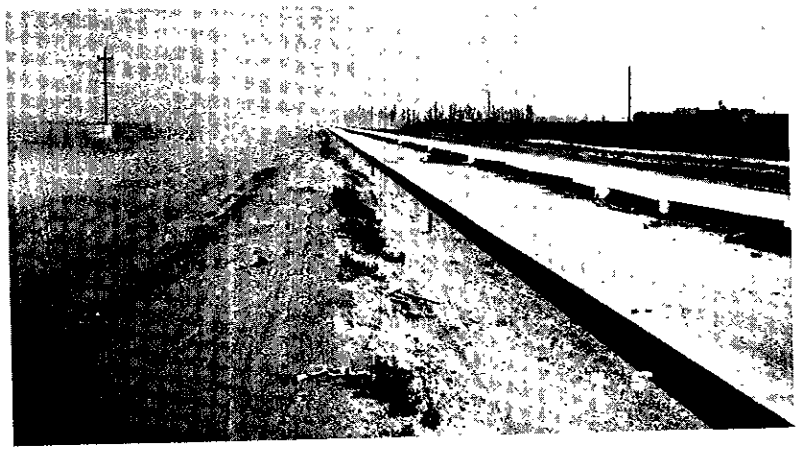

Typical dust formation on untreated sections five hours after cessation of watering operations. Wind speed 20-25 miles/hr. Note reduced visibility on existing travelway on left side of photograph. Median had previously been heavily watered for over a month and tightly compacted by movement of water trucks.

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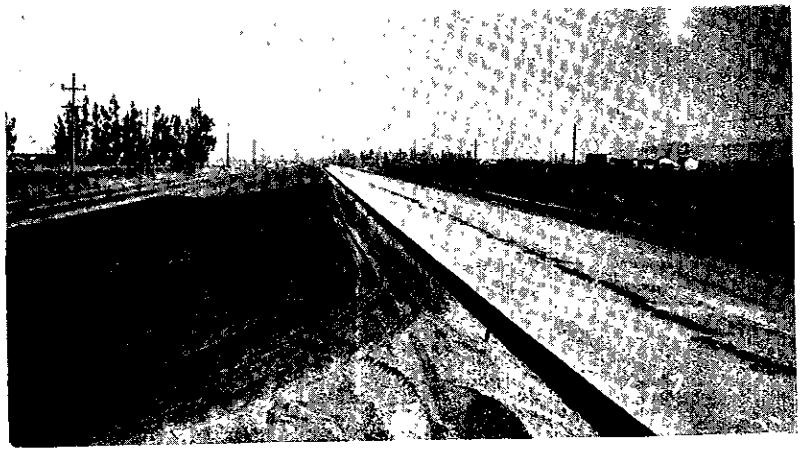
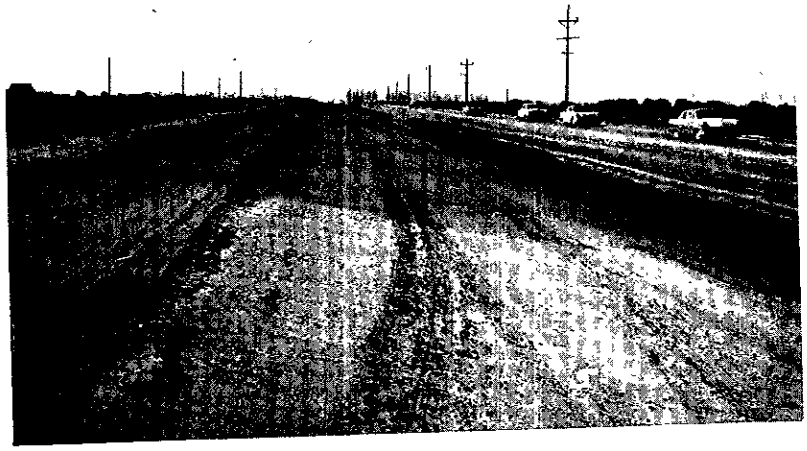


Asphalt mixing emulsion 1:10 section in foreground Petroleum resin 1:7 section in background



Untreated section in foreground Lignin sulfonate 1:10 section in background

Appearance of test sections, 24 hours after application

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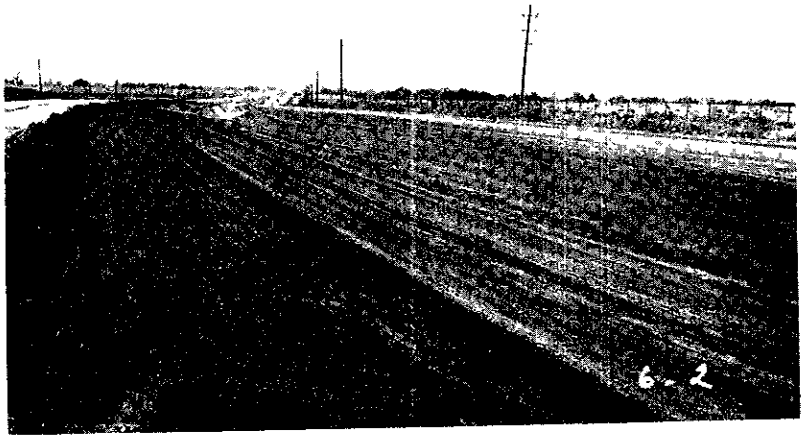
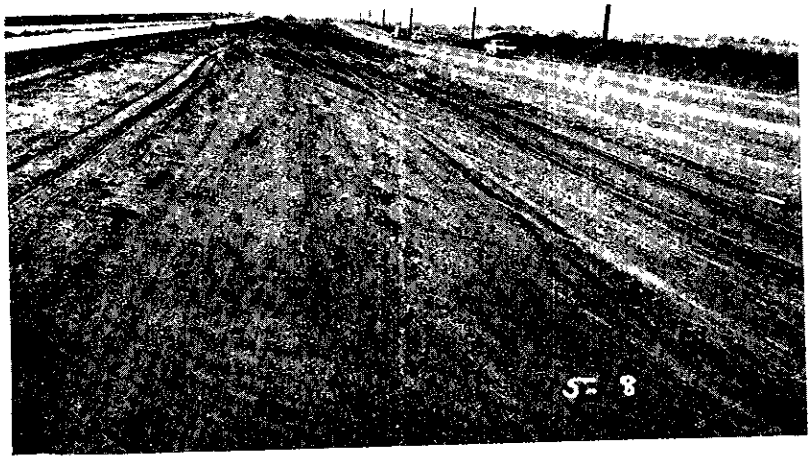


Asphalt mixing
emulsion
1:30



Asphalt mixing
emulsion
1:10 background
Petroleum resin
1:7 foreground

Photographs showing lack of dust formation over treated sections. The top picture shows an area where the most severe dust formation was encountered on the job. These photographs were taken approximately 48 hours after treatment with a wind velocity of 20-25 miles/hr. Compare with photographs shown in Fig. 5.

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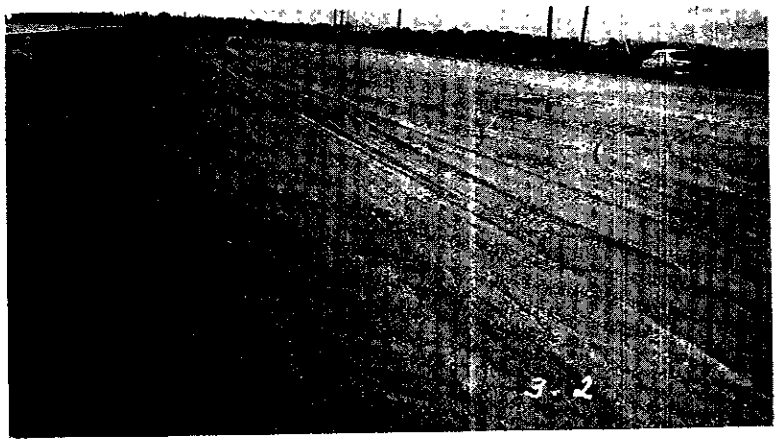
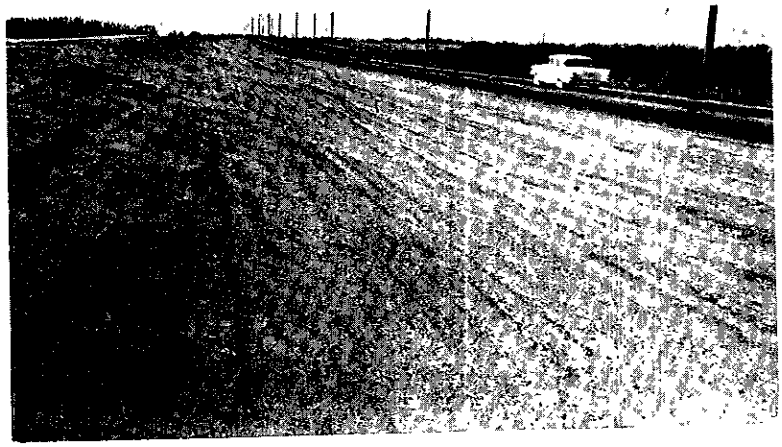
Petroleum resin
1:10 foreground
Lignin sulfonate
1:5 background



Asphalt mixing emulsion
1:10 foreground
1:30 background



Petroleum resin
1:7 foreground
Asphalt mixing emulsion
1:10 background

Typical appearance of various areas of the treated median 35 days after completion of treatment.

Wind velocity at time that photographs were taken was 20-25 miles/hr. No water had been applied to these sections following treatment. Note complete freedom from dust.

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